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House Energy and Commerce Committee

Improving Sports Safety – A Multi-Faceted Approach

March 13, 2014

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Summary Points

- Sports related concussion in youth sports has emerged as a significant public health issue

- Recent studies have identified potential long-term health consequences that may result from the cumulative effects of both concussive and subconcussive impacts

- The road to improving safety for youth athletes will require a multi-factorial approach, including education, rule changes, impact monitoring, improved diagnostic testing and treatment

- Passage of concussion legislation by the Alabama state legislature in 2011 resulted in a 500% increase in patients evaluated for concussion at the Children's of Alabama Concussion Clinic

- Establishment of a multidisciplinary protocol based on best practice guidelines resulted in improved concussion care and decreased use of institutional resources at Children's of Alabama

- Though concussion legislation has resulted in improved recognition and management of concussion in Alabama, primary prevention of sports-related brain injury has emerged as an important priority

- Recent studies of youth football players suggest that a significant proportion of youth head impact exposure takes place during practice, often during outdated drills that are no longer used at the collegiate and professional level

- Education of coaches, athletic trainers and athletic directors and guidelines limiting number of full impact practices and injurious drills can significantly decrease cumulative head impact exposure

- Existing NOCSAE helmet standards should be overhauled in order to reflect current understanding of concussion pathophysiology and foster improved helmet design

- In collaboration with the University of Alabama football program, engineers at UAB have developed a high definition video analysis system that can measure impact conditions for a wide range of collisions. These impact parameters can then be recreated in a high fidelity impact testing laboratory, informing more realistic helmet standards and improved helmet design

Chairman Terry, Ranking Member Shakowsky, and members of the committee: Thank you for inviting me to testify before your committee. I hope my comments regarding our experience in Alabama following concussion legislation are informative to the important work this committee has undertaken to look at Improving Sports Safety. The committee's approach in looking at multi-faceted approaches to this issue is the right way to address the matter and I appreciate the opportunity to contribute to your inquiry.

I am currently an assistant professor in the department of neurosurgery, University of Alabama-Birmingham and an attending pediatric neurosurgeon at Children's (Hospital) of Alabama, one of the nation's largest freestanding pediatric hospitals. With clinical and research expertise in traumatic brain injury, I am the medical director of ThinkFirst Alabama and Research Chairman for the Alabama State Concussion Task Force.

As this committee well knows, the problem of concussion has gained prominence over the past decade, thanks to important research and advocacy work done by scientists, physicians and public health professionals at many centers across the United States. The Centers for Disease Control estimates that between 1.6 and 3.8 million cases of sports-related concussion occur each year, with football having the highest rate of injury. Of significant concern, recent studies have identified potential long-term health consequences, including depression, chronic traumatic encephalopathy (CTE) and other neurodegenerative diseases, associated with repeated head impacts. These findings suggest that, over the long term, significant damage may result from the cumulative effects of both concussive and sub-concussive injury.

As in many states, football has evolved as a major cultural institution in the state of Alabama, with high rates of participation by children starting as early as 8 years of age. The many positive attributes of the game include development of character, teamwork, and sportsmanship. Despite the focus placed on professional and collegiate football in media reports, it is important to keep in mind that greater than 70% of all football players in the US are under 14 years of age. Any efforts directed at improving safety in football will need to address these young players.

Given the above, successfully improving safety for youth athletes is crucial to the future of all impact sports, not just football. It has become clear that the road to improving safety will require a multi-factorial approach, including player and coach education, rule changes, impact monitoring, improved diagnostic tests and treatment. In addition, we believe that helmet performance standards will need to be overhauled in order to foster truly improved helmet design. Our experience in Alabama mirrors that of many other states, and provides insight about the initial successes of the concussion initiative as well as the remaining challenges on the road to improving safety in youth sports.

Concussion Legislation and its Consequences

Following a wave of similar measures around the country, in June 2011, both houses of the Alabama state legislature passed HB-108. The law states : "any youth athlete who is suspected of sustaining a concussion or brain injury in a practice or game shall be immediately removed from participation (that day) and not allowed to return to play until evaluated by a licensed physician and until the athlete receives written clearance to return to play from a licensed physician." The product of several years of advocacy by the Alabama State Concussion Task Force, the measure also required that each local school system and governing body develop guidelines and other pertinent information to inform and educate youth athletes and their parents or guardians about concussion. Education of coaches was also mandated on a yearly basis, with a general curriculum that focused on recognition of concussion as well as requirements of the law.

Passage of the law coincided with a statewide media campaign by Children's of Alabama and ThinkFirst Alabama, aiming to educate parents, coaches, athletic trainers, teachers and administrators about the symptoms of concussion as well as the legal mandate for athletes with suspected concussion to be pulled from the field for medical evaluation. Not unexpectedly, physicians and emergency departments around the state saw a significant increase in referral of youth athletes for concussion care within weeks of passage of the law. The Concussion Clinic at Children's of Alabama in Birmingham, the state's only freestanding pediatric hospital, observed a 500% increase in the number of youth athletes referred for concussion between 2010 and 2011, a trend that has held steady since that time with more than 350 patients evaluated per year. Consistent with the experience of other major centers across the country, the majority of concussions were associated with football, lacrosse and soccer.

To optimize care of this rapidly increasing patient population, UAB and Children's of Alabama developed a multidisciplinary protocol (see Appendix 1) based on best practice guidelines from the Zurich Consensus Statement on Concussion in Sport (2008). After evaluation in the Emergency Department or local pediatricians' office, athletes were referred to the UAB Concussion Clinic at Children's of Alabama for standardized management. In addition to complete physical and neurological examination, patients underwent evaluation with the Sports Concussion Assessment Tool 2/3 (see Appendix 2). Athletes who had a history of multiple concussions, abnormal brain imaging or concomitant cervical spine injury were referred to a pediatric neurosurgeon (JJ). Again, following the Zurich consensus guidelines, athletes were kept out of sports or school until symptom free, then supervised in a graduated return to play and/or return to think program. Approximately 80% of all athletes had resolution of symptoms within 2 weeks; patients with persistent symptoms or neurocognitive issues were referred to a neuropsychologist and the formal traumatic brain injury program supervised by Physical Medicine and Rehabilitation.

A formal study performed in 2012 demonstrated that establishment of the multidisciplinary concussion program, with it standardized referral, management and treatment protocol, resulted in significantly better concussion care and decreased institutional resource utilization. Further analysis of more than 600 patients treated between 2011-2013 found that a previous history of concussion, low presenting SCAT2 score, previously diagnosed ADHD, female gender, and a higher presenting SCAT2 symptom severity score were associated with a higher risk of prolonged (> 2 weeks) recovery from concussion.

Prevention of Sports Related Concussion

Though passage of the law, increased media reporting on the topic, and establishment of the multidisciplinary concussion program have all undoubtedly resulted in improved recognition and treatment of concussion in Alabama, it is clear that much remains to be done in order to prevent sports related brain injury in the first place. In football (and many other sports), there is a culture of toughness and sacrifice for the benefit of the team that discourages youth athletes from reporting symptoms and coaches from pulling players with possible injury. Though attitudes about this among coaches and parents have changed somewhat over time, it is clear from our and others' experience that many concussions still go undiagnosed, with significant consequences for these young athletes.

Recent studies by researchers at Wake Forest University and Virginia Tech following youth football players with helmet-mounted sensor systems have clearly demonstrated that the highest magnitude impacts may approach those seen at the high school level. Given the difficulty of delineating a specific concussion "threshold" using existing helmet accelerometer technology, researchers have begun to shift their focus from concussion to correlating impact exposure over time with advanced imaging techniques and neuropsychological changes. In this vein, researchers at Purdue University have demonstrated changes in functional MRI and cognitive performance over time in football players, even in the absence of diagnosed concussion.

Importantly, studies suggest that a significant percentage of youth players' head impact exposure takes place during practice, oftentimes during outdated drills (supervised by well meaning but untrained coaches) that are no longer performed at the collegiate and professional level. As researchers' attention has turned to the long-term effects of sub-concussive impacts, especially in the developing brain, others and we have focused our efforts on persuasion of coaches, athletic trainers, and athletic directors to limit unproductive impact exposure in practice. Emulating top-level collegiate programs (including the University of Alabama), the Alabama High School Athletic Association recently published non-binding guidelines to limit full contact hitting practices to twice per week.

A recent study of youth players aged 9-12 years by researchers at Wake Forest demonstrated a 37-46% decrease in head impact exposure for players on the team that had instituted rule changes (based on recent Pop Warner mandates) which limited contact in practice to no more than 1/3 of weekly practice time and no more than 40 minutes of a single session devoted to hitting drills. Though it has not been demonstrated whether this also results in a decreased risk of concussion, common sense suggests that suffering 40% fewer impacts to the head over time is better than the alternative.

Given this new emphasis on sub-concussive impacts and head impact exposure over time, some experts have gone so far as to advocate the adoption of a "hit count," similar to the "pitch count" that has been so effective in youth baseball.

By shifting the focus from "concussion" to cumulative head impact exposure, a path to improving safety for youth athletes becomes much more apparent. Limiting the frequency of hitting practices as well as the types of drills done during practice (for example, proscribing Oklahoma drill, bull in the ring and other outdated and unproductive drills) would have the largest effect on safety, significantly reducing head impact exposure for every youth football player in America.

Development of Improved Helmet Performance Standards

In addition to all the above, it has also become clear that football helmet standards, currently defined by the National Operating Committee for Standards in Athletic Equipment (NOCSAE), must be updated to reflect our improved understanding of the etiologies of concussion. Primate studies, finite element modeling, and in vivo helmet accelerometer studies have all demonstrated a role for both linear impact and rotational kinematics in the pathophysiology of concussion. Despite this knowledge, the current NOCSAE standard measures only linear impact protection based on a skull fracture tolerance model developed in the 1960's. The recent Virginia Tech STAR system has been a very important (and controversial) contribution to the ranking of helmet designs based on attenuation of linear impact, and recent work by the same group suggests a lower rate of concussion in players wearing a modern day helmet (like the Riddell Revolution) compared with those wearing a traditional model (like the Riddell VSR).

As mentioned above, when current helmet performance standards were developed, the primary objective was preventing skull fracture, and the testing procedures were never intended to examine the risk of concussion. Further, existing helmet performance standards are based upon a simple drop test of a helmeted head form onto a rigid plate. This testing is not now, nor has it ever been, representative of helmet impacts at any level of football. Further, the testing procedures do not include any rotational loading and therefore do not examine rotational accelerations of the head, which are known to be a primary contributor to concussion.

The severity of on-field collisions is related to a number of impact characteristics, including *closing velocity, impact point on the helmet, player mass,* and *player body alignment.* All of these parameters affect the peak g-loading and velocity change applied to a player's head during on-field impacts. If the risk of player injury is to be measured with any degree of accuracy, all of these impact characteristics must be represented during testing. These important impact parameters have never been accurately measured for any of the popular contact sports, including football, hockey, and lacrosse. These critical indicators of impact severity must be precisely measured in order to provide even the most rudimentary evaluation of a helmet's capability for reducing TBI.

Almost all recent studies of on-field impacts have incorporated accelerometers attached to players' helmets, ears, or mouthpieces. Accelerometer data have been collected on more than 1.5 million helmet-to-helmet and helmet-to-ground impacts. Although these impacts have shed light on the magnitude of accelerations experienced by football players at every level, there is a great deal of important information that cannot be collected using accelerometers alone. Even when properly designed, helmet/head accelerometers and rotational rate transducers can only measure translational and rotational accelerations and velocity changes. Other critical parameters, including closing velocity, specific point of impact, helmet orientation at impact, body mass, and body orientation must be identified by another means. These parameters are best quantified through photogrammetric analysis of game videos. The move to high-definition video and improvements in video analysis technologies have greatly improved both the accuracy and the degree of automation possible with photogrammetric reconstruction of videos from football games. In collaboration with the University of Alabama football program, engineers at UAB have recently developed a robust video analysis software suite that can measure all of these critical parameters for a given impact from two-angle coaching film (see Appendix 3). These parameters can then be used to inform a spectrum of realistic impact reconstructions in the laboratory, with a commensurate ability to study these impacts in detail (see Appendix 4).

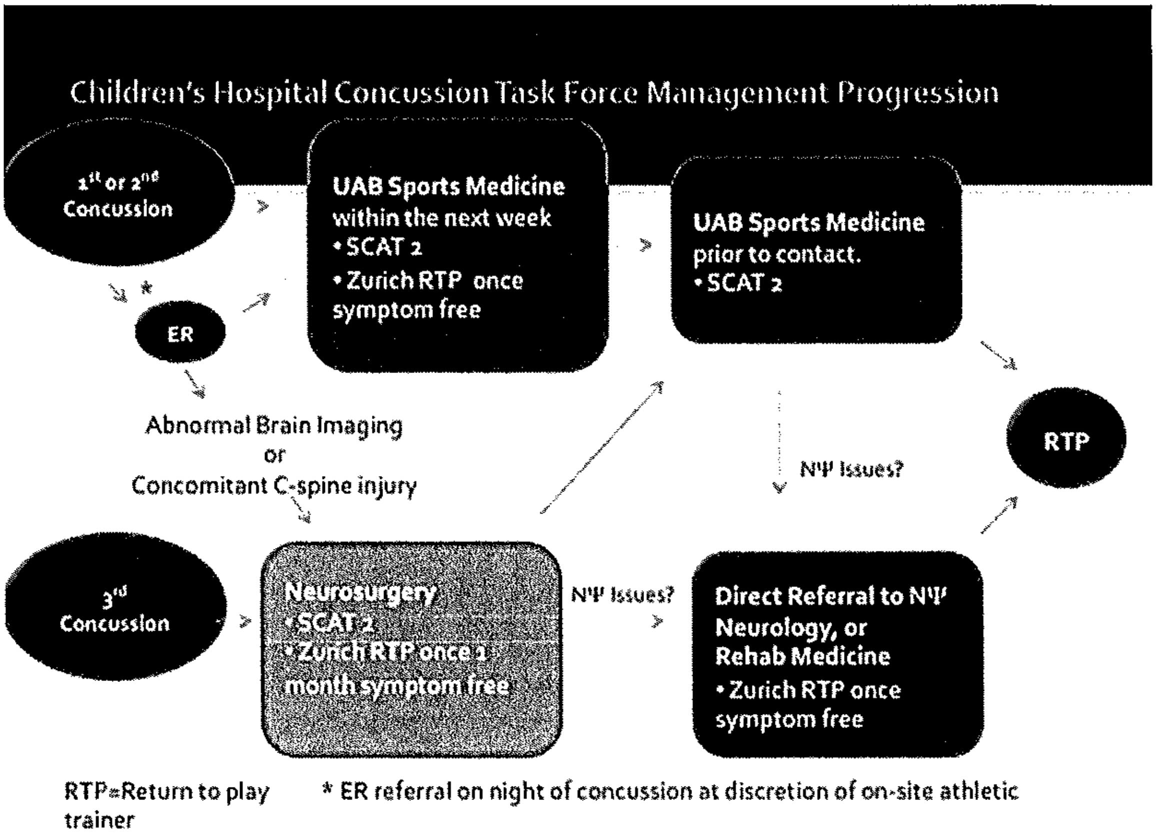
The only way to assure that all relevant impact parameters are properly evaluated is to develop a testing system that is as close to real world collisions as possible. The testing protocol must provide accurate and consistent re-creations of on-field impacts, and it must be able to evaluate the interactions between two different helmet designs. Variations in both impact frequency and magnitude from one player position to the next, and for youth vs. high school vs. collegiate level players are also undoubtedly crucial. For example, linemen experience some degree of helmet impact during almost every play. However, these impacts involve relatively low speeds. On the other extreme, kick returners and wide receivers experience far fewer impacts, but the severity of these impacts can be several times higher than those experienced by linemen. Nevertheless, the possibility must be kept in mind that numerous, low severity collisions may be as injurious as infrequent, high-speed collisions.

Conclusion

The passage of concussion legislation, community education and recent advances in our understanding of head impact exposure in youth athletes have all undoubtedly improved the overall safety of impact sports like football. Nonetheless, much work remains, specifically in the education of coaches/trainers and drafting of policies to limit unnecessary head impact exposure in practice for youth athletes. As part of this multifaceted approach to a complex problem, the development of new helmet standards based on realistic impact conditions is crucial for the development of safer helmets.

Mr. Chairman, thank you for the opportunity to testify and I look forward to your questions.

Appendix 1: Children's of Alabama Multidisciplinary Concussion Management Protocol



Appendix 2: Sports Concussion Assessment Tool 3 (SCAT3)

SCAT3™

Sport Concussion Assessment Tool – 3rd Edition

For use by medical professionals only

Name | Date/Time of Injury: | Examiner:
Date of Assessment:

What is the SCAT3?[1]

The SCAT3 is a standardized tool for evaluating injured athletes for concussion and can be used in athletes aged from 13 years and older. It supersedes the original SCAT and the SCAT2 published in 2005 and 2009, respectively[2]. For younger persons, ages 12 and under, please use the Child SCAT3. The SCAT3 is designed for use by medical professionals. If you are not qualified, please use the Sport Concussion Recognition Tool[1]. Preseason baseline testing with the SCAT3 can be helpful for interpreting post-injury test scores.

Specific instructions for use of the SCAT3 are provided on page 3. If you are not familiar with the SCAT3, please read through these instructions carefully. This tool may be freely copied in its current form for distribution to individuals, teams, groups and organizations. Any revision or any reproduction in a digital form requires approval by the Concussion in Sport Group.
NOTE: The diagnosis of a concussion is a clinical judgment, ideally made by a medical professional. The SCAT3 should not be used solely to make, or exclude, the diagnosis of concussion in the absence of clinical judgement. An athlete may have a concussion even if their SCAT3 is "normal".

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific signs and/or symptoms (some examples listed below) and most often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (e.g., headache), or
- Physical signs (e.g., unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour (e.g., change in personality).

SIDELINE ASSESSMENT

Indications for Emergency Management

NOTE: A hit to the head can sometimes be associated with a more serious brain injury. Any of the following warrants consideration of activating emergency procedures and urgent transportation to the nearest hospital:

- Glasgow Coma score less than 15
- Deteriorating mental status
- Potential spinal injury
- Progressive, worsening symptoms or new neurologic signs

Potential signs of concussion?

If any of the following signs are observed after a direct or indirect blow to the head, the athlete should stop participation, be evaluated by a medical professional and **should not be permitted to return to sport the same day** if a concussion is suspected.

Any loss of consciousness?	Y	N
"If so, how long?"		
Balance or motor incoordination (stumbles, slow/laboured movements, etc.)?	Y	N
Disorientation or confusion (inability to respond appropriately to questions)?	Y	N
Loss of memory:	Y	N
"If so, how long?"		
"Before or after the injury?"		
Blank or vacant look:	Y	N
Visible facial injury in combination with any of the above:	Y	N

1 Glasgow coma scale (GCS)

Best eye response (E)	
No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4
Best verbal response (V)	
No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5
Best motor response (M)	
No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion/Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6
Glasgow Coma score (E + V + M)	of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

2 Maddocks Score[3]

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

What venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week/game?	0	1
Did your team win the last game?	0	1
Maddocks score		of 5

Maddocks score is validated for sideline diagnosis of concussion only and is not used for serial testing.

Notes: Mechanism of Injury ("tell me what happened"?):

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle until cleared to do so by a medical professional. No athlete diagnosed with concussion should be returned to sports participation on the day of injury.

BACKGROUND

Name: ________ Date: ________
Examiner: ________
Sport/team/school: ________ Date/time of injury: ________
Age: ________ Gender: M F
Years of education completed: ________
Dominant hand: right left neither
How many concussions do you think you have had in the past? ________
When was the most recent concussion? ________
How long was your recovery from the most recent concussion? ________
Have you ever been hospitalized or had medical imaging done for a head injury? Y N
Have you ever been diagnosed with headaches or migraines? Y N
Do you have a learning disability, dyslexia, ADD/ADHD? Y N
Have you ever been diagnosed with depression, anxiety or other psychiatric disorder? Y N
Has anyone in your family ever been diagnosed with any of these problems? Y N
Are you on any medications? If yes, please list: Y N

SCAT3 to be done in resting state. Best done 10 or more minutes post excercise.

SYMPTOM EVALUATION

3 How do you feel?

"You should score yourself on the following symptoms, based on how you feel now".

	none	mild		moderate		severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22)
Symptom severity score (Maximum possible 132)

Do the symptoms get worse with physical activity? Y N
Do the symptoms get worse with mental activity? Y N

self rated — self rated and clinician monitored
clinician interview — self rated with parent input

Overall rating: If you know the athlete well prior to the injury, how different is the athlete acting compared to his/her usual self?

Please circle one response:
no different — very different — unsure — N/A

Scoring on the SCAT3 should not be used as a stand-alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion. Since signs and symptoms may evolve over time, it is important to consider repeat evaluation in the acute assessment of concussion.

COGNITIVE & PHYSICAL EVALUATION

4 Cognitive assessment

Standardized Assessment of Concussion (SAC)[4]

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score		of 5

Immediate memory

List	Trial 1		Trial 2		Trial 3		Alternative word list		
elbow	0	1	0	1	0	1	candle	baby	finger
apple	0	1	0	1	0	1	paper	monkey	penny
carpet	0	1	0	1	0	1	sugar	perfume	blanket
saddle	0	1	0	1	0	1	sandwich	sunset	lemon
bubble	0	1	0	1	0	1	wagon	iron	insect
Total									

Immediate memory score total of 15

Concentration: Digits Backward

List	Trial 1		Alternative digit list		
4-9-3	0	1	6-2-9	5-2-6	4-1-5
3-8-1-4	0	1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0	1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0	1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6
Total of 4					

Concentration: Month in Reverse Order (1 pt. for entire sequence correct)

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan 0 1

Concentration score of 5

5 Neck Examination:

Range of motion Tenderness Upper and lower limb sensation & strength
Findings: ________

6 Balance examination

Do one or both of the following tests.
Footwear (shoes, barefoot, braces, tape, etc.) ________

Modified Balance Error Scoring System (BESS) testing[5]
Which foot was tested (i.e. which is the non-dominant foot) Left Right
Testing surface (hard floor, field, etc.) ________
Condition
Double leg stance: Errors
Single leg stance (non-dominant foot): Errors
Tandem stance (non-dominant foot at back): Errors

And/Or

Tandem gait[6,7]
Time (best of 4 trials): ________ seconds

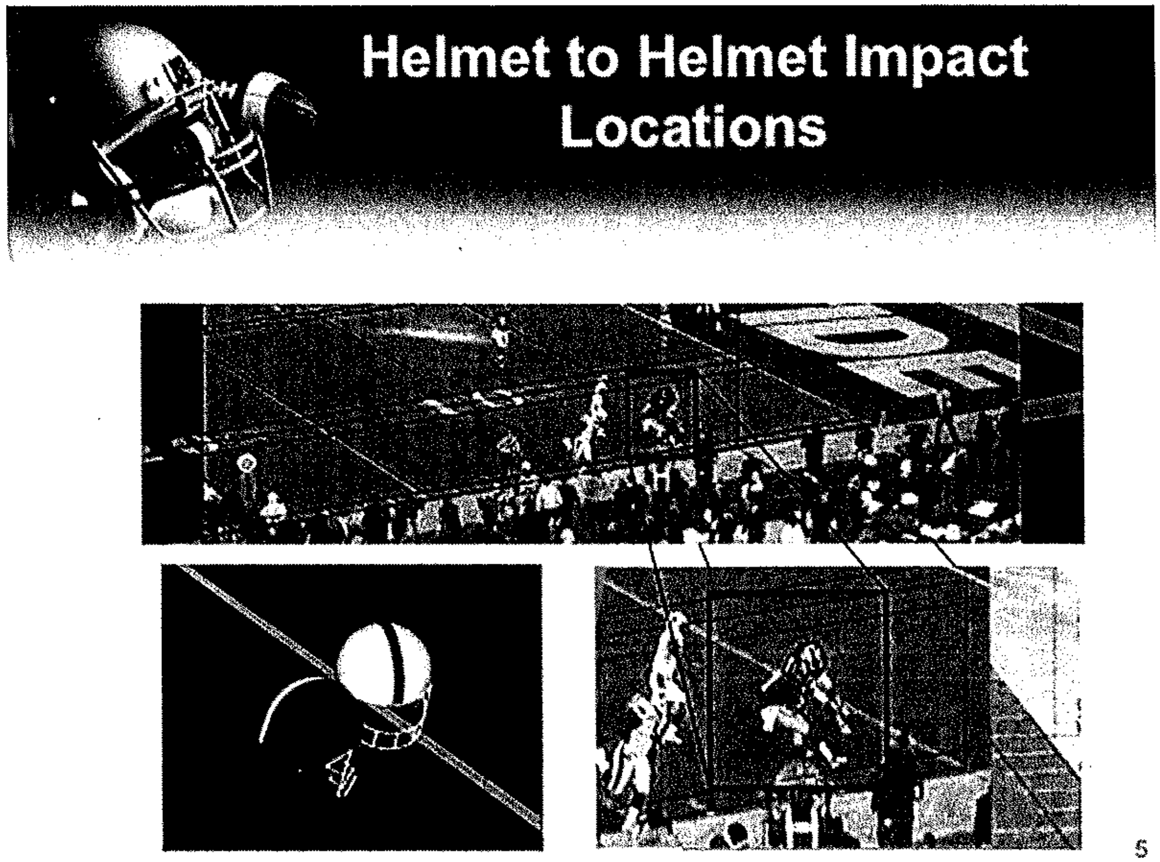
7 Coordination examination

Upper limb coordination
Which arm was tested: Left Right
Coordination score of 1

8 SAC Delayed Recall[4]

Delayed recall score of 5

Appendix 3: High Resolution Photogrammatic Impact Analysis



Appendix 4: Impact Reconstruction in UAB Laboratory